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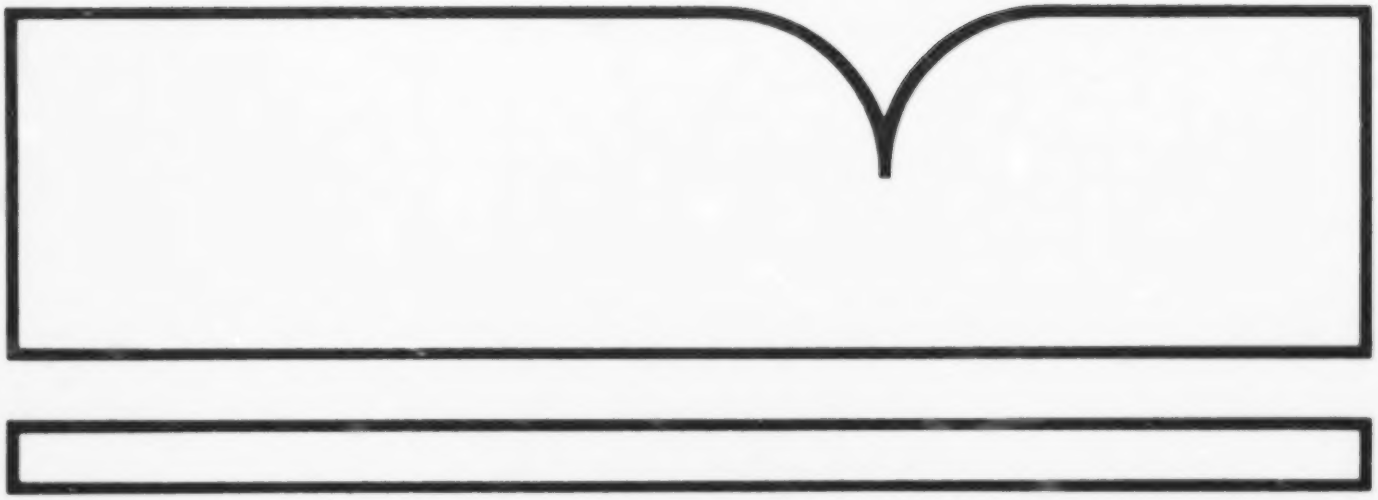

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Effects of Ground ULV Applications of Fenthion on Estuarine Biota IV. Lethal and Sublethal Responses of an Estuarine Mysid[1]

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ABSTRACT

Low-level exposure to fenthion, following ground ULV application of this organophosphate pesticide, resulted in increased mortality and sublethal growth retardation of *Mysidopsis bahia*. These two processes would reduce population production of this crustacean, which serves as an important link in the estuarine food web. Significantly higher rates of oxygen consumption of exposed mysids 8 days after fenthion application accompanied the reduced growth of exposed mysids. The results of this field study confirm those of earlier laboratory studies, indicating that short-term measurements of metabolic dysfunction in mysids exposed to pesticides may be used to predict altered production rates in mysid populations.

INTRODUCTION

Hazard assessment associated with actual use conditions of pesticides should include an examination of the more pesticide-sensitive, non-target members of the exposed field community. Considering the close phylogenetic relationships between crustaceans and the insect pests toward which pesticides are directed, it is not surprising that crustaceans have been shown to be particularly sensitive to pesticides. Toxicity tests over the last decade have shown the mysid shrimp, *Mysidopsis bahia*, to be one of the most sensitive members of the estuarine communities in the northeast Gulf of Mexico to pesticides (for a review see Nimmo and Hamaker, 1982).

[1]Contribution No. 523d of the Gulf Breeze Environmental Research Laboratory.

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Mysids serve as an important link in the estuarine food chain between primary producers and commercially important fishes that utilize the estuary as a nursery (Odum, 1971; Chao and Musick, 1977; Sheridan and Livingston, 1979). Laboratory studies have shown that production rates of *M. bahia* populations exposed to low concentrations of pesticides may be reduced by increased mortality among individual mysids or by sublethal inhibition of growth and reproduction rates (McKenney, 1982, 1985). These studies, furthermore, have suggested that elevated respiration rates of mysids might be useful as a monitoring tool for identifying the presence of sublethal concentrations of pesticides responsible for reducing the production rates of mysid populations.

The purpose of this study was to evaluate lethal and sublethal responses of an estuarine mysid (*M. bahia*) during field applications of fenthion, an organophosphate insecticide used in various mosquito control programs in Florida. In addition to observations on survival of caged mysids, growth and respiration rates of mysids were monitored following ULV application of fenthion.

MATERIALS AND METHODS

At daily intervals before each fenthion application, juvenile *M. bahia* were collected [as they were released] from laboratory cultures and maintained under optimal laboratory conditions (25°C and 20 $^{0}/_{00}$ S) (McKenney, unpublished information) until needed in the field. Mysids from laboratory cultures of 20 $^{0}/_{00}$ S were placed in 10 $^{0}/_{00}$ S seawater and allowed to adjust to this lower salinity for 5 to 6 hr prior to placement in low-salinity conditions (5 to 15 $^{0}/_{00}$) of the field site. On the morning prior to each application of fenthion, juvenile mysids of the same age (10- to 14-days-old) were placed in conical, nylon mesh cages (10 mysids per cage) at both an exposure site (Site 1) and a reference site (Clark et al., this issue). For the majority of sprays, 4 cages were utilized at each site. On two occasions (6 June 1983 and 13 June 1983), a larger than usual number of available mysids permitted more cages to be placed at each site. The appropriateness of the reference site was determined by comparing survival of caged mysids at both the reference and exposure sites without fenthion application.

The cone-shaped cages were similar in design to those used successfully by Shuskina (1972) to monitor growth of mysids in the Sea of Japan. The top of the double-layered nylon mesh cone (363 µm, inner layer; 1000 µm, outer layer) was attached to the top half of a 1000 ml polypropylene bottle. The bottom of the cone was attached to an inverted top half of a 250 ml polypropylene bottle. The entire cage was approximately 28 cm high and was held in place by a floating plexiglass platform.

Survival of caged mysids in both the exposed and reference site was monitored the morning after the evening spray, approximately 12 hr after the ground ULV application of fenthion. Mysids surviving the spray on 13 June 1983 were returned to their appropriate cages for an additional period of time prior to metabolic and/or growth observations.

Approximately 60 and 180 hr after the third spray on 13 June 1983, 10 to 15 mysids were subsampled from two cages at both the reference and exposed site and returned to the laboratory to determine oxygen consumptions rates. In the laboratory, mysids from each field site were individually sealed in 5-ml all-glass syringes that contained 20 ml of fully oxygenated seawater collected from the appropriate field site. These syringes were incubated in a 26°C water bath along with control syringes without mysids. After approximately 18 hr, a 75-100 µl sample of the fluid in the syringe was injected into a Radiometer® BM53 Mk2 Blood Micro System with attached PHM71 Mk2Acid-Base Analyzer, and a direct measurement of the partial pressure of oxygen was recorded. Each mysid was removed from the syringe, briefly rinsed in distilled water, and placed in an oven at 60°C to dry for 48 hr. Dry weights of individual mysids were measured to the nearest 0.1 µg on a Cahn 21 Automatic Electrobalance.

Differences between partial pressures of oxygen in control respirometers (syringes with no mysid) and respirometers that contained a mysid were attributed to mysid respiration. Respiration rates of individual mysids were calculated as weight-specific oxygen consumption rates (µg 0_2 mg^{-1} dry weight h^{-1}).

Examination of growth patterns of mysids after the 13 June 1983 spray was based on differences between dry weights of mysids from the reference and exposed sites. Differences in survival, respiration rates, and dry weights between mysids from reference and exposure sites were analyzed by a two-sample t-test that compared means from the two sites with $\alpha = 0.05$ (Zar, 1974).

RESULTS AND DISCUSSION

Survival of caged *M. bahia* juveniles after 36 hr did not differ significantly ($p > 0.05$) between exposed and reference sites in the absence of a fenthion spray (Table 1, 6 June 1983). The reference site may, therefore, be considered appropriate and the difference in survival of caged mysids between the two sites following a fenthion spray may be attributed to the pesticide.

Differences between survival of caged mysids in the reference site and the exposure site treated with fenthion correlated well with measured concentrations of fenthion in water near the mysid cages at the exposure site. After the first spray (10 May 1983), survival was significantly different between caged *M. bahia* in the exposed site and the reference site (Table 1); measured fenthion concentrations in water close to the exposed mysids were approximately 0.5 µg/l 1 hr after the spray, 0.1 µg/l after 6 hr, 0.01 after 12 hr, and non-detectable after 18 hr (Moore et al., this issue). Similar concentrations were found in the water near caged mysids during the first hour after the second spray (13 June 1983). However, the duration of fenthion exposure was much less after the second spray; approximately 0.2 µg/l was present 3 hr after the spray and none detectable 12 hr after the spray (Moore et al., this issue). Not only did the efficacy test demonstrate the treatment of fenthion to be ineffective in controlling mosquitoes during the second spray (Clark et al., this issue), but no significant mortality among mysids could be attributed to the second fenthion spray (Table 1, 13 June 1983).

Similar correlations between survival of caged *M. bahia* and measured fenthion concentrations were noted during the third spray. The only detectable concentration of fenthion in the vicinity of the mysid cages after the third spray was 0.01 µg/l and that occurred 30 min after the spray (Moore et al., this issue). No signifi-

Table 1. Survival of caged mysids (*Mysidopsis bahia*) from a reference site and an exposed site (Site 1) sprayed with fenthion on three different dates during a field study. Each value is the mean (x) and standard deviation (SD) of N replicate cages containing 10 mysids per cage.

Date of Spray	Spray Conditions	No. of hours after spray	Survival Percentage			
			Reference Site		Exposed Site	
			x ± SD	(N)	x ± SD	(N)
10 May 1983	ULV Spray	12	68 ± 13	(4)	35*± 10	(4)
6 June 1983	No Spray	36	82 ± 9	(12)	89 ± 19	(12)
13 June 1983	ULV Spray	12	69 ± 12	(12)	66 ± 19	(10)
11 July 1983	ULV Spray	12	68 ± 28	(4)	48 ± 21	(4)

*Significantly less than reference site ($p < 0.05$) (Student's t-test).

Table 2. Sublethal physiological responses of caged juvenile mysids (*Mysidopsis bahia*) to fenthion exposure during a field study. Each value is the mean (x) and standard deviation (SD) of N individual replicates.

Date of Spray	No. of hours after spray	Reference Site		Exposed Site	
		x ± SD	(N)	x ± SD	(N)
13 June 1983					
Growth	60	290 ± 202	(10)	260 ± 114	(10)
(µg dry wt)	180	483 ± 129	(15)	367*± 123	(15)
Respiration rate	60	9.38 ± 2.13	(10)	10.61 ± 3.54	(10)
(µg O_2 mg^{-1} h^{-1})	180	5.73 ± 0.59	(10)	7.06*± 1.43	(10)

*Significantly different from the control ($p < 0.05$) Student's t-test).

cant differences in survival were seen between mysids from the exposed and reference sites (Table 1, 11 July 1983) 12 hr following the spray.

Following the second spray (13 June 1983), which produced no significant mortality in caged *M. bahia*, several sublethal physiological responses of mysids from both the exposed and reference sites were monitored (Table 2). While no significant differences existed between weights of mysids from the exposed and the reference site 60 hr after the spray, exposed mysids weighed less 8 days after the spray, suggesting retarded growth rates after sublethal fenthion exposure. Significantly higher rates of oxygen consumption of exposed mysids 8 days after the spray accompanied the reduced weights of exposed mysids, suggesting bioenergetic disruptions in mysids exposed sublethally to fenthion in the field. Similar results have been reported for *M. bahia* exposed to sublethal concentrations of pesticides through an entire life cycle in the laboratory (McKenney, 1982, 1985). Increased metabolic demands on mysids exposed in the laboratory to pesticides, as indicated by higher respiration rates, reduced the amount of assimilated energy available for production of new tissue, resulting in lower juvenile growth rates. The results of this field study, therefore, confirm those of earlier laboratory studies; short-term measurements of metabolic dysfunction in mysids may predict altered production rates in mysid populations.

Both lethal and sublethal responses of *M. bahia* to fenthion under actual use applications, as described in this paper, have ecological implications. Production of juvenile populations without continuous recruitment from adjoining populations is the outcome of two opposing processes: increased weight of individuals in the population and decreased numbers of individuals in the population due to mortality (Winberg, 1971). Increased mortality and sublethal growth retardation of mysids following low-level exposure to pesticides, therefore, would result in reduced population production of this crustacean which serves as an important link in the estuarine food chain between primary producers and commercially important fish utlizing the estuary as a nursery.

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